

[0240] One example uses a brake mechanism to control the position or velocity of a joint.

[0241] The present subject matter includes the exoskeleton as well as the control environment for a skeleton.

[0242] In one example, the system is for use in a surgical or medical environment wherein a user in a remote location is able to control a robot or other structure to deliver medical care. This may include manipulating objects, performing surgery, examinations, or providing therapy. In one example, haptic information is provided to the user. In one example, a minimally invasive surgical procedure can be performed using the present subject matter.

[0243] One example of the present subject matter is configured to be worn by a user. The position and alignment of the rotation axis of the exoskeleton joints relative to the user's anatomical joints allows the user to safely manipulate the exoskeleton links without endangering the user. In one example, the user is in a seated position and the exoskeleton is mounted on a wall behind the user. In one example, the exoskeleton is mounted on a wheelchair in which the user sits.

[0244] In one example, the present subject matter is implemented as a prosthesis in that it substitutes or replaces a limb of the user. As such, the control signals for the exoskeleton are derived from other sources, such as sEMG sensors attached to other portions of the user's body, or from a master device or controller.

[0245] In one example, the present subject matter includes three physical points of contact with the exoskeleton. For example, the exoskeleton is in contact with the human arm at the hand, the upper arm and the lower arm. At each point of contact, the system exchanges energy and information between the user and the present subject matter. The exchanged information can take the form of control signals such as force or pressure. The exchanged energy can take the form of a force applied by the exoskeleton to the user or a force applied by the user to the exoskeleton. If, for example, the exoskeleton exerts a force, then the arm will be forced to move along a certain trajectory. In addition, if the user exerts a force at a point of contact, then, as a function of the control algorithm being executed, the exoskeleton will respond and move along a particular trajectory.

[0246] Gravity (or other load force) can act on the exoskeleton to exert a force on the human operator.

[0247] In addition to the examples noted herein, the system can be configured to operate in a mode between a passive state (where the user's arm is moved based on a signal received from the exoskeleton) and an active state (where the user provides the signal to move the exoskeleton). In other words, the system can be operated at a middle position along the spectrum between active and passive. In such a case, the exoskeleton provides some level of assistance and some level of resistance. This mode allows graduated assistance and resistance and may prove beneficial in a rehabilitative or training application.

[0248] The exchange of information can be at different levels. For example, the sensors can be located at the interface between the user's arm and the exoskeleton. Such sensors can be used to discern the user's intention and when a force is exerted thereon by the user, the exoskeleton

responds. At another level, the interfaces are separated. As such, a physical exchange enables exchange of energy between the exoskeleton and the user and a separate interface is provided to exchange information at a different point in the system (for example, at the neural level). If the exoskeleton does not respond in the manner intended by the user, then the user is given an opportunity to correct in which case the feedback is derived from monitoring the joint (pivot). In one example, the feedback is at the physical level and the command is disposed at either the physical level or at a different place (such as the neural level).

[0249] The point of contact for the sensors can be at various points along the length of the link and need not be located at a joint center. For example, a strain gages can be located between the point of contact with the arm and the structure of the exoskeleton such that forces passing through the body and the system are also passing through the single point for each of the three links (upper, lower and hand).

[0250] The points of contact can be in the form of two semicircular braces, each wrapping the forearm and the upper arm, and at a handle held the user's hand. Force-torque sensors (for example, strain gages) can be located between the handle and exoskeleton and at the two braces. The sensors provide information as to load or energy.

[0251] Various types of transducers (sensors) are contemplated. For example, an image based system of transducers can be used in which landmarks (on the user or the exoskeleton) are monitored by an optical sensor. In other examples, an encoder or stepping motor is used to provide information as to position or force.

[0252] In one example, the length of an exoskeleton link is adjustable. In one example, the position and alignment of a joint of the exoskeleton is adjustable.

[0253] In one example, a myoprocessor provides control of the exoskeleton structure and the myoprocessor is coupled to a sensor that is coupled to the user's brain (either invasively or non-invasively). The brain can be trained to provide a control signal for operating the exoskeleton.

[0254] The present system can be used in a variety of applications. For example, the system can be used for physiotherapy and rehabilitation, a neural signaling device, a training device, and a haptic or virtual reality device.

[0255] For physiotherapy and rehabilitation, the present system can be used as an automatic physiotherapy device, for assessment of a disability, and as a power device.

[0256] Consider use of the present system for physical therapy or rehabilitation. When rehabilitating a patient, the therapy work transitions through various phases. Initially the work is directed to increasing the range of motion of a joint or limb. At a later stage, and after having achieved a particular range of motion, the work is directed to assisting the patient in an active manner (not just passively). At this stage, the patient is expected to provide a portion of the energy to cause the motion and the system provides some level of energy. At yet another stage of the therapy, the work is directed to strengthening the muscle capabilities and includes applying a resistive force to resist the motion of the user. At this stage, the system operates like an exercise machine.